Data Report

Geotech Data Report Kittitas Valley Wind Power Project

Prepared for

Zilkha Renewable Energy

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Contents

Introduction

Purpose and Scope

This geotechnical exploration was conducted to evaluate general subsurface conditions in the proposed project area, to support the Energy Facility Site Evaluation Council (EFSEC) permit application. This phase of permit exploration is only preliminary, and is intended to gain general geotechnical information. Additional exploration and evaluation is necessary to provide geotechnical design information. The work was authorized October 9, 2002, in Task Order No. 3 between CH2M HILL and Zilkha Renewable Energy. The scope of the geotechnical exploration included the following:

- Review geologic and available subsurface information
- Perform a site reconnaissance to identify geology, potential geologic hazards, and proposed test pit locations
- Conduct an exploration of subsurface conditions consisting of nine test pit excavations
- Conduct laboratory testing of selected soil samples
- Prepare this data report summarizing the findings

Project Description

The proposed Kittitas Valley Wind Power Project is located within the Kittitas Valley area of Kittitas County in south central Washington. The Project is located east of the Cascade Range, north of the Yakima River. The project area lies on both sides of State Highway 97, near Bettas Road, approximately 19 kilometers (km) (12 miles) northeast of Ellensburg, Washington (see the Project Area and Test Pit Location Map at the end of this report).

The proposed Kittitas Valley Wind Power Project includes the construction of 10 strings of wind turbines (labeled A through J) along ridges that generally run north to south from the Wenatchee Mountains to the north of the project. Each different string contains between 4 and 27 wind turbines, and range in length from 0.8 to 4.1 km (0.5 to 2.6 miles). Turbines within a string are identified by their sequential number in a string, such as A_1, A_2, and so forth. Individual turbines are connected by an underground electrical conduit, and all strings are linked back to the proposed project substation through either underground or overhead transmission lines. The proposed strings that are part of the project are shown on the map provided at the end of this report.

In general, the wind turbines proposed for this project are 3-bladed rotors with a radius of 30 to 45 meters (100 to 150 feet). The rotors and machine house (nacelle) sit atop a mast that is 60 to 76 meters (200 to 250 feet) high. Mast diameters are commonly 4 to 5 meters. Turbines are typically supported by spread footings with foundation anchoring.

The project area is a 3 by 7 kilometer (2 by 4.5 mile) portion of land that consists primarily of long, north-south trending ridges. Between the ridges are ephemeral and perennial creeks that flow into the Yakima River, which is located just south of the Project area. Slopes within the project area generally range from 5 to 20 degrees, but can reach 40 degrees or more in the transverse direction to the ridges. Elevations in the project area and adjacent lands range from approximately 660 to 1050 meters (2165 to 3445 feet) above sea level. The majority of the project area is open range with minimal vegetation. The vegetation is dominated by native bunchgrass and low shrubs, such as bitterbrush and stiff sage. Most of the ridgetops proposed for development consist of dry, rocky grassland.

Limitations

This report has been prepared for the exclusive use of Zilkha Renewable Energy for specific application to the Kittitas Valley Wind Power Project. This report has been prepared in accordance with generally accepted geotechnical engineering practice. No other warranty, express or implied, is made.

The information contained in this report is based on data obtained from test pit logs that depict subsurface conditions only at the specific locations and times indicated, and only to the depths penetrated. Subsurface conditions and water levels at other locations may differ from conditions at these locations.

CH2M HILL is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or reuse of the subsurface data without the express written authorization of CH2M HILL.

Technical Data

Field Exploration

The field exploration was completed on October 30 and 31, and November 1, 2002. Initially, 12 test pits were planned at the project area. However, after one turbine string was eliminated, 9 total test pits were excavated at various locations along the string lines during the exploration (ZG-03 through ZG-10, and ZG-12).

Test pits were excavated by Fulleton-Pacific Construction, Inc., of Ellensburg, Washington, using a John Deere 310D rubber-tired backhoe, and a 0.3-meter (12-inch) bucket. Subsurface conditions were observed and logged by a CH2M HILL geotechnical engineer. Field copies of test pit logs are presented in Appendix A. Soil samples were examined in the field and visually classified in general accordance with ASTM D2488—Description and Identification of Soils (Visual-Manual Procedure). The field classifications are shown on the test pit logs in Appendix A. Test pits were located after completion in the field with a hand-held Global Positioning System (GPS). The accuracy of the locations using this type of GPS is approximately within 6 m. All locations and elevations are based on the North American Datum (NAD 1983). Coordinates given for horizontal location are based on the Universal Transverse Mercator (UTM) grid. Table 1 presents a summary of the test pit locations and depths.

TABLE 1
Test Pit Summary

Test Pit	UTM Northing	UTM Easting	Elevation (m)	Nearest String Position	Depth (m)
ZG-03	5,222,328	673,162	741.9 (2,434 feet)	A_3	3.0 (10 feet)
ZG-04	5,219,707	674,532	691.3 (2,268 feet)	B_{10}	2.7 (9 feet)
ZG-05	5,220,284	674,748	695.2 (2,281 feet)	C_3	2.7 (9 feet)
ZG-06	5,225,504	673,673	825.1 (2,707 feet)	F_1	1.2 (4 feet)
ZG-07	5,227,887	674,596	978.4 (3,210 feet)	G_1	2.4 (8 feet)
ZG-08	5,224,802	674,715	770.2 (2,527 feet)	G_{17}	2.7 (9 feet)
ZG-09	5,226,329	676,126	860.4 (2,823 feet)	H_7	1.5 (5 feet)
ZG-10	5,222,774	675,921	740.4 (2,429 feet)	I_{14}	3.4 (11 feet)
ZG-12	5,222,179	674,705	744.0 (2,441 feet)	E_2	2.7 (9 feet)

Note: Test pits ZG-01, ZG-02, and ZG-11 were not excavated.
All locations and elevations are based on NAD 83. UTM coordinates are zone 10T, NAD 83, meters.

Laboratory Testing

Samples collected during the preliminary field exploration were delivered to a laboratory for testing of index parameters and for verifying field classifications. Laboratory testing was conducted by Strata, Inc., of Boise, Idaho. Testing included the following:

- ASTM D2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock
- ASTM D4318: Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422: Particle-Size Analysis of Soils

The laboratory test results are summarized in Table 2. Complete geotechnical laboratory test results are provided in Appendix B.

TABLE 2
Laboratory Test Result Summary

Test Pit	Sample Type	Sample Depth Interval (m)	Soil Type ASTM D 2488	Moisture Content (%)	Atterberg Limits (%)			% Passing 75 μm Sieve
					LL	PL	PI	
ZG-03	Bulk	0.3-1.5	SM					34
	Bag	0.6	SP	15.6				
	Bag	1.5	SC	24.1				
	Bag	2.7	ML	21.9	26	22	4	
ZG-05	Bulk	1.5-2.7	GP-GM					8
	Bag	1.5	SP-SM	8.0				
ZG-06	Bulk	0.3-1.2	GP-GM					6
	Bag	0.6	SP	12.2				
	Bag	0.9	SP	9.7				
ZG-07	Bag	0.9	GP	23.2				
ZG-08	Bulk	0.6-2.4	GM					36
	Bag	0.9	CL	19.2				88
	Bag	1.5	CL	22.6	43	23	20	
	Bag	2.4	ML	21.1				52
ZG-09	Bag	0.6	SM	10.5				
	Bag	1.5	SM	22.1				
ZG-10	Bulk	0.6-2.1	SP-SM					9
	Bag	0.9	SANDSTONE	9.8				
	Bag	1.8	SP	11.1				
	Bag	3.4	SP-SM	10.8				12
ZG-12	Bag	0.6	SP	10.3				
	Bag	1.2	SP-SM	20.2				12
	Bag	2.4	SP-SC	13.0				12

LL = Liquid Limit.
PL = Plastic Limit.
PI = Plasticity Index.
GP = Poorly graded gravel with sand.
GP-GM = Poorly graded gravel with silt and sand.
GM = Silty gravel.
ML = Silt, silt with sand/gravel, and sandy/gravelly silt
SM = Silty sand.
SC = Clayey sand.
CL = Lean clay.
SP = Poorly graded sand with gravel.
SP-SM = Poorly graded sand with silt and gravel.

Interpretation

Geologic Conditions

The project is located in the upper Kittitas Valley, between the Kittitas Valley Syncline and the Naneum Ridge Anticline. The project lies in the Columbia Intermontane physiographic province (Freeman et al. 1945), located on the western edge of the Columbia River Plateau, bordering the Cascade Range. The general geologic conditions are characterized by a mantle of cemented gravel and cobble alluvium overlying both the Grande Ronde Basalt formation and the Ellensburg formation (Tabor et al., 1982).

Mainstream and Sidestream Alluvium Formations. These formations consist of Pliocene-age epiclastic rocks, derived from the Grande Ronde Basalt formation, the Ellensburg formation, and other rock types including quartz, quartzite, opal, and chert. Near the project, this alluvium is weakly cemented and comprised mainly of well-rounded cobble and boulder clasts of the Grande Ronde Basalt, with surface material characterized by thick rinds and spheroidal weathering. The material ranges from a few meters up to 15 meters in thickness.

Grande Ronde Basalt. This material forms the predominant bedrock unit in the area, and consists of multiple basalt flows that are sometimes interbedded with the Ellensburg formation. This formation is a subgroup of the Columbia River Basalt Group, and has been described to have a thickness up to 300 meters, although the thickness in the project vicinity is not known.

Ellensburg Formation. This formation is made up of sandstone, siltstone, and conglomerate derived from volcanism in the Cascade Range. The material is weakly lithified, and is interbedded with the Grande Ronde Basalt formation. Exposures of this formation in the project vicinity were found to be highly weathered and were typically extremely weak. The thickness of the Ellensburg formation is not known.

Seismicity

The project area lies within seismic Zone 2B, based on the 1997 Uniform Building Code (UBC 1997). Seismic sources include the Cascadia Subduction Zone (CSZ), intraslab, and crustal (local fault) sources (Geomatrix 1995). Each of these events has different causes, and therefore, produces earthquakes with different characteristics (that is, peak ground accelerations, response spectra, and duration of strong shaking). The two source mechanisms associated with the CSZ are currently thought to be capable of producing moment magnitudes of approximately 9.0 and 7.5, respectively (Geomatrix 1995).

A single fault is mapped in the project area, trending east-west near the intersection of Highway 97 and Bettas Road. This fault is a high-angle fault with its north side downthrown, and crosses Highway 97 approximately 760 meters (2493 feet) north of Bettas Road. Running east, the fault is inferred in a location that intersects the H, I, and J turbine strings. The fault location underlies the southernmost turbine in string H (H_{25}). It passes approximately between turbines I_{12} and I_{13} on the I-string, and approximately between turbines J_9 and J_{10} on the J-string. The fault is estimated to have last been active during the Miocene epoch. The total length of the fault is approximately 4 kilometers (2.5 miles). The approximate location of this fault is shown on the map attached at the end of this report.

The peak ground acceleration (PGA) at the site corresponding to a 10 percent probability of exceedance in 50 years (approximately 500-year return period) is between 0.119 g and 0.121 g at the bedrock surface, according to USGS seismic hazard mapping. This value of PGA on rock is an average representation of the acceleration most likely to occur at the site for all seismic events (crustal, intraplate, or subduction) for the 500-year return period.

Subsurface Conditions

The predominant subsurface conditions for the project consist of dry to moist, weak to moderately cemented gravels and cobbles overlying basalt bedrock. At other locations (ZG-03 and ZG-10), cemented silt and sandstone was encountered. At one test pit location excavated in a drainage swale (ZG-08), the subsurface consisted of fine-grained alluvium that exhibited only slight cementation. At all locations, the upper 0.1 to 0.3 meter (4 to 12 inches) was dry to moist silt, vegetated sparsely by grasses and brush.

Cemented Gravels and Cobbles. This is the predominant subsurface material across the site, consisting of rounded to well-rounded epiclastic gravels and cobbles, with varying percentages of sand and silt. The material was typically moderately cemented within the upper 2 to 5 feet, with local variations. Cementation is silicic, not carbonateous. Natural moisture contents ranged from 8 to 23 percent, and the material was tested to contain between 6 and 12 percent fines (silt and clay). The majority of the material ranged in size from 0.08 to 0.25 meter in diameter (3 to 10 inches), although some boulders were encountered, up to 1.2 meters (4 feet) in diameter.

During excavation of test pits, dry and dusty conditions were common, with moisture increasing with depth. Discussions with contractors suggests that in the spring and early summer months, this material is saturated and often difficult to drive equipment on. The material is fairly easy to excavate at this time of year, whereas in the late summer, fall, and winter, excavation can be extremely difficult, particularly in the cemented zone. Stability of excavation walls in this material ranged from poor to good, depending on the size of cobbles and degree of cementation. This material is interpreted to be part of the Mainstream and Sidestream Alluvium formations (Tabor et al., 1982).

Cemented Silt and Sandstone. In test pit ZG-03, a highly cemented silt was encountered from 0.3 to 0.9 meter (1 to 3 feet) below ground surface. This test pit was located in a small, relatively flat area that showed signs of seasonal ponding in the vicinity. It is believed that this material is a fine-grained alluvium and loess (wind-blown silt and sand) that has become cemented. The moisture content of this material ranged from 16 to 24 percent, and contained a varying percentage of fine sand. The gravels and cobbles described previously were encountered below this material, at an approximate depth of 2.7 meters (9 feet). This material was extremely difficult to excavate in the cemented zone, although excavation stability was excellent.

In test pit ZG-10, a weak sandstone was encountered for the entire depth of the excavation. This material was cemented from 0.6 to 2.1 meters (2 to 7 feet). Natural moisture content ranged from 10 to 11 percent, and contained between 9 and 12 percent fines. Excavation was the easiest in this material, and excavation stability was moderate to good. This material is believed to be part of the Ellensburg formation (Tabor et al., 1982).

Fine-Grained Alluvium. Test pit ZG-08 was excavated in a small drainage tributary to Dry Creek. At this location, approximately 2.4 meters (8 feet) of lean clay and silt was encountered above the cemented gravels and cobbles described previously. Natural moisture content of this material ranged from 19 to 23 percent, and contained between 12 and 48 percent sand and coarse-grained materials. A single Atterberg Limits test in this material resulted in a liquid limit of 43 percent, and a plasticity index of 20 percent. The consistency of this material was hard, according to pocket penetrometer measurements. Excavation in this material was fairly easy, and excavation walls showed good stability.

Groundwater Conditions

Groundwater was not observed in any of the test pits excavated at the project area. However, in some of the swales and small drainages, groundwater is anticipated to be present seasonally, following periods of precipitation and snowmelt. Groundwater is not anticipated on the ridges where most of the strings are located. However, localized pockets of saturated subsurface soils are anticipated to be encountered on ridges in places where surface water infiltrates the subsurface and collects above zones of cementation. Cemented soils have lower porosity and permeability, and were found in the upper 1 to 7 feet at the project area.

References

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Uniform Building Code. 1997.

Insert Project Area and Test Pit Location Map (11x17)

Appendix A

Test Pit Logs

Appendix B

Laboratory Test Results